Space Weather Technical Forecast

Issued on Tuesday, 13 December 2022 at 00:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight chance of M-class flares (R1-R2; Minor-Moderate radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with occasional low-level C-class flares recorded at GOES16. The largest of these flares was a C3.4 at 12/0036 UTC from the vicinity of one of the smaller groups in the far northwest, AR3156. No significant looking CME was associated with this flare despite its drawn out X-ray signature.
This is just one of up eleven sunspot regions on the visible disc, with the 24-hour period seeing up to three new developing bipolar regions. Along with AR3156 in the northwest, these were the most dynamic on the disc in the period. All regions are now considered to be simple unipolar or bipolar regions, with the largest regions AR3153 (Fho/Beta), AR3157 (Esi, Beta) and AR3163 (Esi/Beta) remaining relatively stable during the period. No Earth-directed Coronal Mass Ejection (CMEs) are forecast.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by DSCOVR. The solar wind was at mostly Slightly Elevated levels. The phi angle was resolutely towards the Sun (negative) throughout. The solar wind density showed a roughly level tendency near the long-term average 5-10 ppcc), while the IMF was stable and weak, below 8nT throughout. The north-south component showed a range between +7/-6nT, with no protracted aligned or anti-aligned periods noted. The net result of the above solar wind measures was for Quiet to Unsettled geomagnetic activity (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2 MeV), as observed by GOES16, has been at Background to occasionally Moderate levels. The associated 24-hour fluence remained well below Active (1e8 integrated pfu). Observed fluence at 12/2100UTC was 4.76e6 integrated pfu, with a rising trend at GEO.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a Chance of isolated M-class flares each day, and these are currently most likely from AR3163, AR3153 or AR3157, which are the largest regions on the visible disc, or AR3156 which is the most magnetically complex. Further arriving regions over the coming days may see a further slight increase in activity.

Solar Wind / Geomagnetic Activity: No Earth-directed CMEs currently feature in the forecast. A high speed stream (HSS) related to a minor looking unnumbered coronal hole may graze Earth on day 1 (13th). Muted effects are predicted by persistence, if any. Solar winds are currently at slightly elevated levels and this HSS may give a bump to elevated levels for a time, with solar winds seeing a decline by day 3 (15th). Geomagnetic activity is likely to be Quiet to Unsettled, with a chance of isolated Active intervals on day 1 (13th). Predominantly Quiet

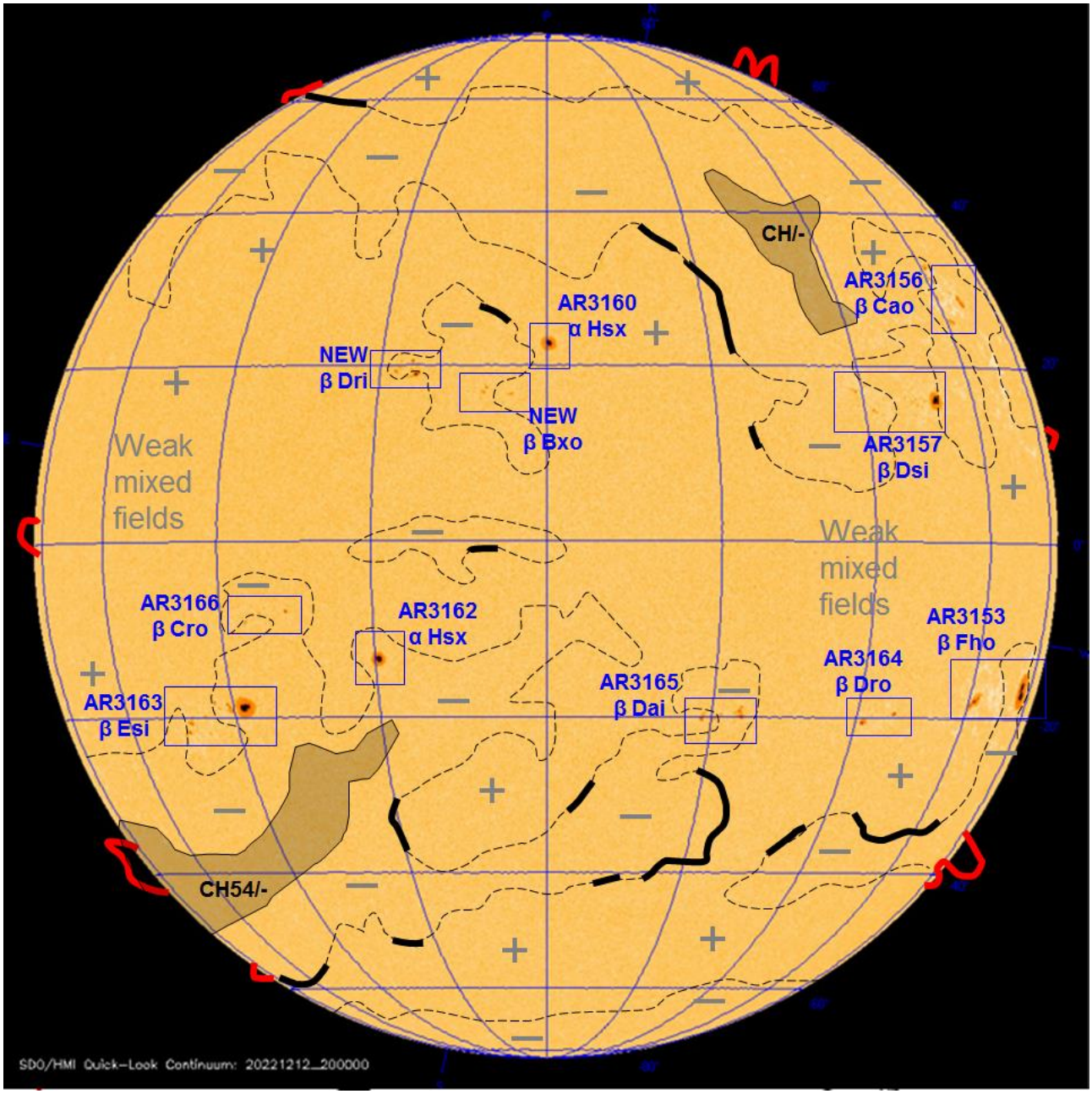
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

geomagnetic activity is expected by day 3 (15th).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) is expected to remain at Background levels throughout, with a daily Slight Chance of seeing S1+ levels if any significant flares occur. High energy electron flux (greater than 2 MeV) are forecast to remain mainly at Background to Moderate levels, with an increasing trend, which brings a chance of diurnal maximum High levels (1000pfu) each day. The corresponding high energy electron fluence is expected to remain below the Active (1e8 integrated flux) threshold, despite the upward trend.

Figure 1. Solar Analysis Valid 2000UTC, 12 December 2022.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Storms:

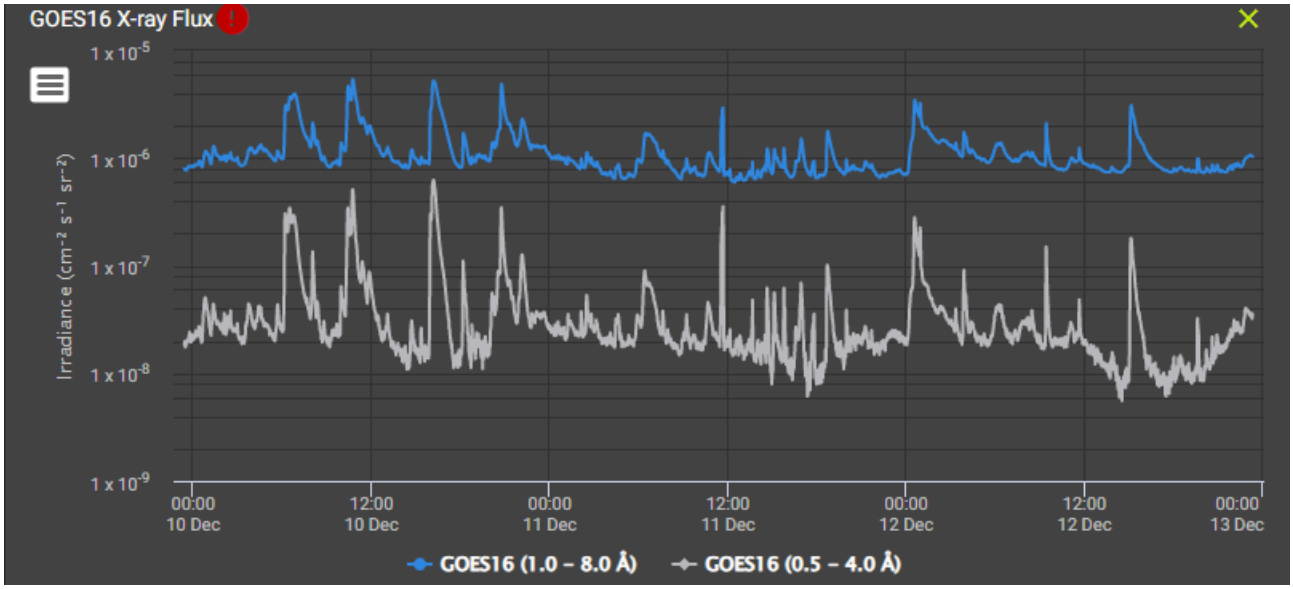
No Earth-directed CMEs feature in the current forecast. A high speed stream (HSS) may arise from a tenuous northern solar hemisphere feature that was present on last rotation, but delivered almost no discernible effect at Earth. MOSWOC Enlil model output has dealt with this feature in a very erratic manner, with some suggestions of a HSS reaching 500km/s, but with an onset time varying by 24 hours. There is not yet any sign of any fast wind at STEREO A, and a slower and perhaps later HSS is therefore favoured, if present at all. All considered, geomagnetic activity is likely to be Quiet to Unsettled, with a chance of isolated Active intervals on day 1 (13th) if Earth connects to the fast wind from the un-numbered coronal hole to the north. Predominantly Quiet geomagnetic activity is expected by day 3 (15th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	1	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Figure 2: X-ray flux plot at GEO over past three days with a number of C-class flares.



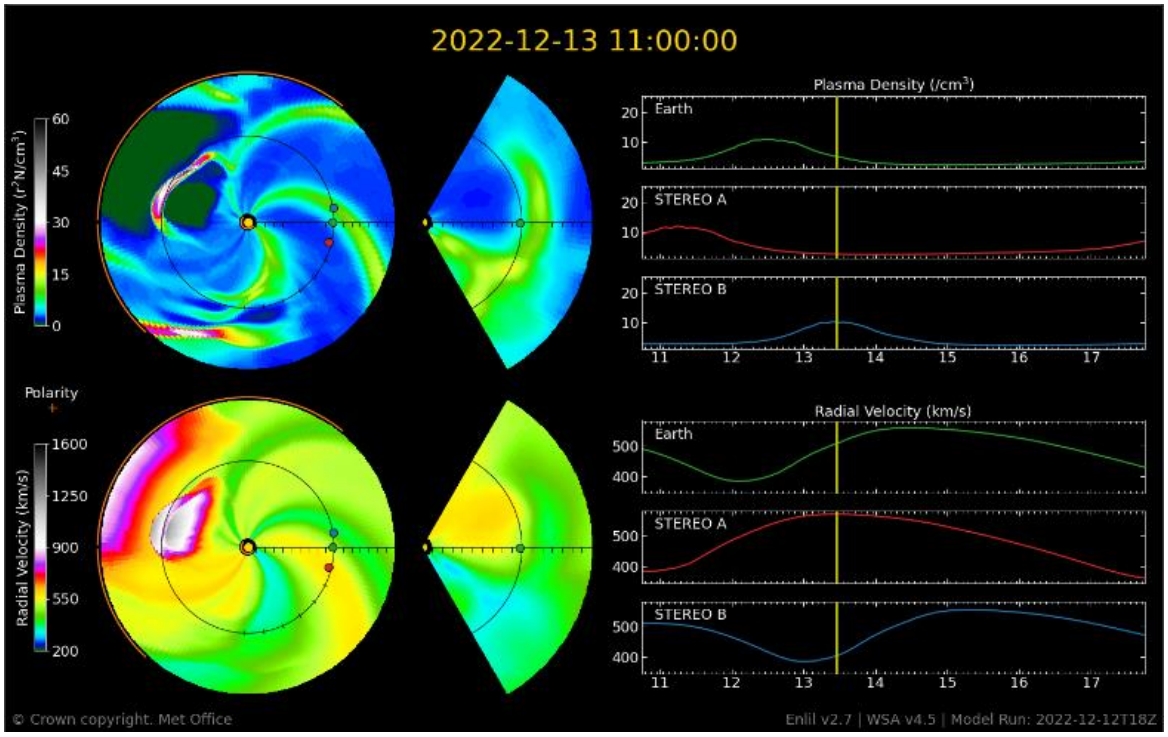
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Radio Blackouts - X-Ray Flares:
There are eleven sunspot regions on the Earth facing disc, although the majority are long-term stable residents and either simple dipoles, or else unipoles. Even the recent arrival of AR3163 over the southeastern limb has now stabilised somewhat after an entry onto the disc characterised by mid-ranking C-class flares and (non-Earth directed) CMEs. The daily probabilities for any M-class flares have been revised downwards relative to the raw probabilities of the contributing sunspot groups, with AR3153 and AR3157 in particular proving far less active than their Zurich classes of Fho and Esi would suggest. The balance of numbers on the Earth-facing side might rise a little further due to the Carrington locations of returning sunspot groups rotating onto the visible disc. The main contenders potentially being Ex-3148, 49 and 51. By midweek, AR3153 and AR3156, will transit across the western limb. This is the rationale for the initial slight rise in daily probability of an M-class flare, followed by a moderation in probability for days 3 and 4 (15th and 16th).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	30	25	25
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: Met Office ENLIL model showing the potential arrival time of the next HSS which is considered too early.



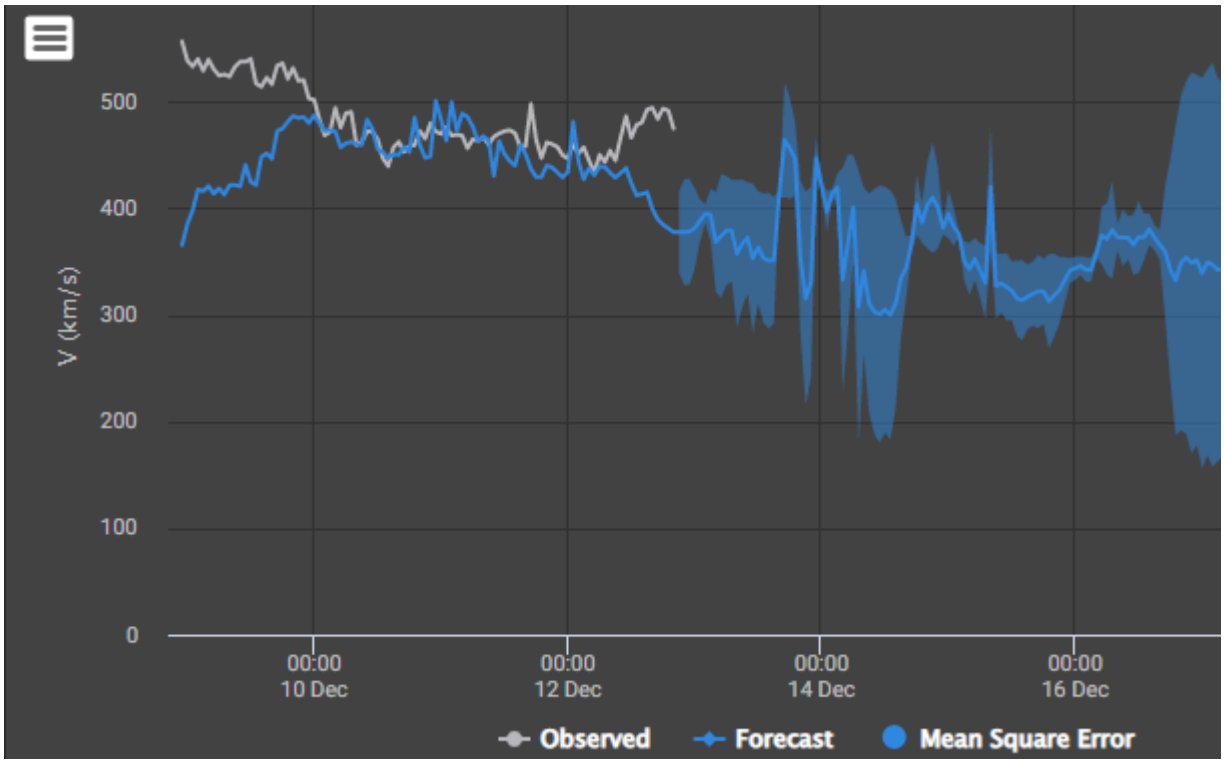
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) is most likely to remain at Background levels throughout. There remains a daily Slight Chance of S1 or greater levels at GEO if any significant flares were to occur. The 5% risk is mainly contributed by the presence of the three larger sunspots on the Earth facing side of the solar disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Met Office Solar Winds Prediction Model (SWPM) indicating a mostly downward trend.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2 MeV) is showing minor signs of reacting to the recent fast wind from CH53/-, and the currently observed Normal Background to Moderate flux levels will probably be maintained through the period with High levels at diurnal maximum increasingly likely over the period, especially if the HSS from CH##/- arrives at Earth with solar winds reaching the elevated range. The 24-hour integrated electron fluence is forecast to remain below the active level and a slight chance of 10-20% is given in the forecast tables for this level to be breached.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	20	20	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: High energy electron flux and Met Office REFM output.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.